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FACTORS INFLUENCING AVERAGE MILK PRODUCTION AND INCOME OVER
FEED COST IN DHIA HERDS

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Milk production is the primary measure in all testing programs. In addition, testing programs in most States also include a wealth of information on an individual cow and on a herd basis. This includes such information as milkfat production, feed consumption, recommended concentrate feeding, days dry, pregnant, and in milk, cumulative milk and fat production for the lactation, value of product, income over feed cost, and various other economic values for judging cost and profitability. This information is calculated in the central processing labs from data obtained by the DHIA supervisors at the farm, in order to provide the dairyman with valuable information that he can use to assess the overall economic status of the dairy operation and to make intelligent management decisions. The primary end result of this entire program is to enable the dairyman to run a more efficient and profitable enterprise.

Comparatively little research has been conducted to judge the usefulness of the DHIA herd average estimates. Direct evaluation of the accuracy of the estimates is not possible using the testing information alone. However,

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indirect measures of the adequacy of the DHIA records can be made by studying relationships among the different factors.

Results are reported below of research that has been conducted to evaluate the worth of DHIA herd average data by examining the relation of milk production and estimated income over feed cost (IOF) to various types of herd average data. Primarily, the investigation centered on two questions: (1) How closely is herd average milk production related to estimated income over feed cost per cow? (2) How are other herd average feeding and management estimates related to milk production and IOF?

To study these questions, annual DHIA reports for Holstein herds covering the 1960-64 testing years were examined to locate herds with the following information: (1) value of product, (2) average concentrates (grain) fed per cow, (3) succulent forage (silage), (4) dry forage (hay), (5) pasture, (6) cost of concentrates, (7) total feed cost, and (8) percent days in milk during the year. A total of 8,048 annual herd averages from 23 States met these requirements. The number of herds by State is shown in table 1. The majority of the herds were from New York and Pennsylvania.

Table 2 contains the averages of all herds for the different factors studied, together with a measure of the relative amount of variation in each factor. Prices for concentrates (grain) and milk are included in table 2. Grain price was calculated by dividing the estimated cost of grain by the amount of grain reported fed. Similarly, the price of milk per hundredweight was obtained by dividing the reported value of product by the herd average milk production per cow.

These data represent conditions in DHIA herds 4 to 8 years ago. Since the period 1960-64, herd size, milk production, and grain feeding have all increased, while hay and pasture feeding have decreased.

TABLE 1.--Number of annual herd averages by State

State	No. of herd averages	State	No. of herd averages
Maine-----	60	Minnesota-----	307
New Hampshire-----	85	Iowa-----	331
Vermont-----	224	Missouri-----	50
Massachusetts-----	260	North Dakota-----	24
Rhode Island-----	8	Nebraska-----	32
Connecticut-----	188	Kansas-----	59
New York-----	1,978	Delaware-----	91
New Jersey-----	172	Maryland-----	310
Pennsylvania-----	2,961	Virginia-----	107
Ohio-----	38	West Virginia-----	136
Indiana-----	88	North Carolina-----	170
Illinois-----	369		
		Total-----	8,048

TABLE 2.--Averages and relative variation of factors studied
in DHIA Holstein herds ^{1/}

Factor	Average	Relative variation
		<u>Percent</u>
Herd size (cows)-----	40.4	48
Milk (lb.)-----	12,011	13
Fat (pct.)-----	3.70	5
Fat (lb.)-----	445	14
Days in milk (pct.)-----	84.7	4
Concentrates (100 lb.)-----	39.1	23
Succulent forage (100 lb.)---	95.5	46
Dry forage (100 lb.)-----	42.7	32
Pasture (days)-----	161.8	25
Value of product (dollars)---	555.92	19
Milk price/cwt. (dollars)----	4.63	14
Cost of concentrates (dollars)	118.07	31
Feed cost (dollars)-----	237.04	24
Feed cost/cwt.milk (dollars)-	1.98	22
Income over feed cost(dollars)	318.88	25
Grain price/cwt. (dollars)---	3.02	19

^{1/} Averages are on a herd average per cow per year basis.

The measure of relative variation of each factor reflects two different sources of variation. One source is the inherent herd differences that occur in real life. A second source comes from errors made in estimating these factors at the farm. For instance, fat percent, percent days in milk, milk production, and milk price all exhibit relatively low variation and are probably all measured with a relatively high degree of accuracy. On the other hand, the greatest amount of variation occurs in estimates of silage and hay fed, with concentrates and pasture showing somewhat less variation. Although a high degree of herd differences is involved in these estimates, the variation is undoubtedly due in part to errors made in estimating consumption. On most farms the amount of hay and silage fed is difficult to assess and is usually reported from figures provided to the DHIA supervisor by the dairyman. Commonly, the dairyman gauges the number of feet of silage fed from a silo or the number of bales of hay fed to the herd in a given period of time. These estimates must then be averaged over the total number of cows consuming the feed. Generally, it is not practical for the DHIA supervisor to obtain an independent estimate. Since most cows are normally fed at least part of their concentrates individually at the time of milking, it is possible to obtain a more accurate estimate of concentrate feeding level. The number of days on pasture likewise can be determined with a greater degree of accuracy than amounts of hay and silage. However, the determination of the energy content of pasture is more difficult than for the other feed components. For these reasons, the reporting of feed consumption is unofficial or Owner-Sampler in nature.

PREDICTING MILK PRODUCTION

The first phase of the study was directed toward evaluating the usefulness of feeding and management factors in predicting the annual herd average milk yield. The higher the influence that these feed and management factors have on

production, or cost of production, the greater the benefit to the dairyman from having this information.

The analysis was based on comparisons of herds in the same county tested in the same year. By studying the data in this manner, most of the errors associated with consistent overestimation or underestimation by a single DHIA supervisor are removed. Herds in the same county and testing year would usually be tested by the same supervisor. In addition, State and regional biases are circumvented by this procedure.

The factors studied were concentrates fed, silage fed, hay fed, days on pasture, percent days in milk, and herd size. Herd size was considered simultaneously in order to adjust the other factors for any differences that may have existed between large herds and small herds.

The results of two separate analyses are given in table 3. In the first analysis, (table 3, analysis one) all the factors listed above were evaluated for their effects on production. The effect of each factor is stated as the number of pounds of annual herd average milk yield change for each increase and one unit in the factor. Grain, silage, and hay are expressed in 100-pound units, pasture is in days, days in milk is a percentage, and herd size is in one-cow units. Table 3 indicates that all factors except herd size had a positive effect on milk yield. For example, there was an average increase of 98.3 pounds of milk for each 100-pound increase in the amount of grain fed per cow. On the other hand, there was a decrease of 1.1 pounds of milk per cow for each additional cow in the herd. To judge the usefulness of herd size in predicting milk production, the same analysis was carried out, leaving out herd size. These results are also shown in table 3 under analysis two. The accuracy of predicting milk yield with all six variables was 42.1 percent while the accuracy decreased only to 42.0 percent when herd size was omitted. Thus, herd size was of little or no value

TABLE 3.--Effects of various factors on herd average milk production ^{1/}

Factor	Pounds change in milk per unit change in factor, holding other factors the same	
	Analysis I	Analysis II
Grain (100 lb.)-----	+98.3	+98.2
Silage (100 lb.)-----	+8.8	+8.8
Hay (100 lb.)-----	+17.2	+17.2
Pasture (days)-----	+5.0	+5.0
Percent days in milk (1 percent)-----	+115.6	+115.8
Herd size (cows)-----	-1.1	-----

^{1/} Milk is expressed in units of annual herd average yield per cow (pounds).

TABLE 4.--Effects of estimated feeding levels on milk production

Feed component	Pounds change in milk per unit change in factor, holding the other feed amounts the same		Relative importance ^{1/}
Grain (100 lb.)-----	+105.0		27.7
Silage (100 lb.)-----	+9.4		3.4
Hay (100 lb.)-----	+18.8		1.5
Pasture (days)-----	+5.4		1.0

^{1/} Relative importance expressed in terms of relative amount of variation in milk production explained by the factor, as a ratio to the amount explained by days on pasture.

in estimating production in this situation. It should be kept in mind that herd size differences, which are expressed through differences in amounts of feed or percent days in milk, are still reflected in the results in the second analysis. As can be seen in table 3, the effects of the remaining factors were changed very little when herd size was ignored.

As indicated in table 3, percent days in milk has a strong relationship to milk yield. There is an increase of about 116 pounds in the herd average milk production for each 1 percent increase in percent days in milk. Since there may well be increased feeding levels in herds with above average days in milk, the effects of percent days in milk may be associated with those of the various feeding factors. In order to evaluate the full impact of the feeding factors, a third analysis was conducted, the results of which are shown in table 4.

The effects of the various factors shown in table 4 are only slightly different from those in table 3. The effects of the four feeding components are greater when percent days in milk is ignored, indicating that herds with cows in milk a greater proportion of the time also have more successful feeding programs. However, ignoring percent days in milk decreases the accuracy of predicting milk production to only 35.7 percent. This indicates that percent days in milk has other effects on yield in addition to reflecting a higher level of feeding. For instance, percent days in milk appears to be extremely important in reflecting the success of a dairyman's breeding program for settling cows within a reasonable time after calving and for maintaining good herd reproductive health. Percent days in milk probably also reflects the inherent persistency of the cows as well as the dairyman's ability to keep cows in milk for normal full length lactations.

Table 4 also provides a measure of the relative importance of the four feeding estimates to herd average milk production. There are many ways in which the importance of

these factors could be compared. The method of comparison chosen was to evaluate the feed components on the basis of the amount of the variation in milk production explained by each. Days on pasture was used as the standard of comparison, since it was the least important factor. For example, table 4 indicates that concentrates was most useful in predicting milk yield, being 27.7 times as important as pasture. Silage was 3.4 times as useful as pasture, while hay was only 1.5 times more valuable than pasture. These evaluations should not be confused with the energy contributions of the various factors to the total ration fed.

As a further illustration of the relationships of the feed estimates to herd average milk production, the effects listed in table 4 are shown graphically in figures 1-4. These graphs should be interpreted as the average effects of the feeding factors over the entire range of herd conditions represented in the data. There may be considerable variation in the physical nature and energy value of the feeds from one herd to another, particularly in the case of forages. Forages differ widely in moisture content, stage of maturity at harvesting, palatability, and in their crop origin. These variations lead to great fluctuations from herd-to-herd in the energy value of the forages for feeding purposes. These differences may partially account for the difficulty in relating estimated forage consumption to changes in milk yield. If both the amounts and energy value of forages were accurately assessed, forage consumption would undoubtedly show a closer relationship to milk production. Also, the relationships would be expected to change from one set of feeding conditions to another. However, it was not possible to distinguish different feeding systems in the data reported through DHIA.

Table 4 and figures 1-4 clearly indicate that the reported amount of concentrates is most closely related to herd average milk production. In general, the responses to each of the components (concentrates, hay, silage, and

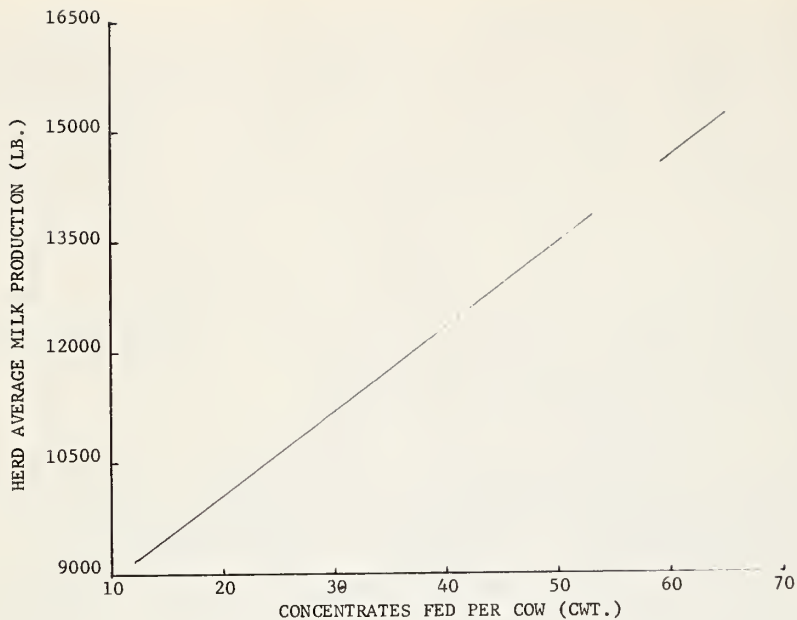


Figure 1.--Relationship between herd average milk production and concentrate feeding levels, holding forage intake constant.

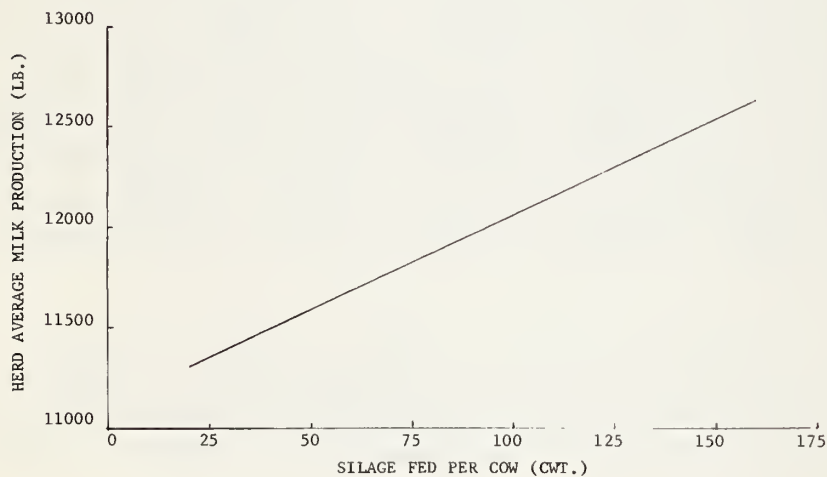


Figure 2.--Relationship between herd average milk production and silage feeding levels, holding grain and other forage intake constant.

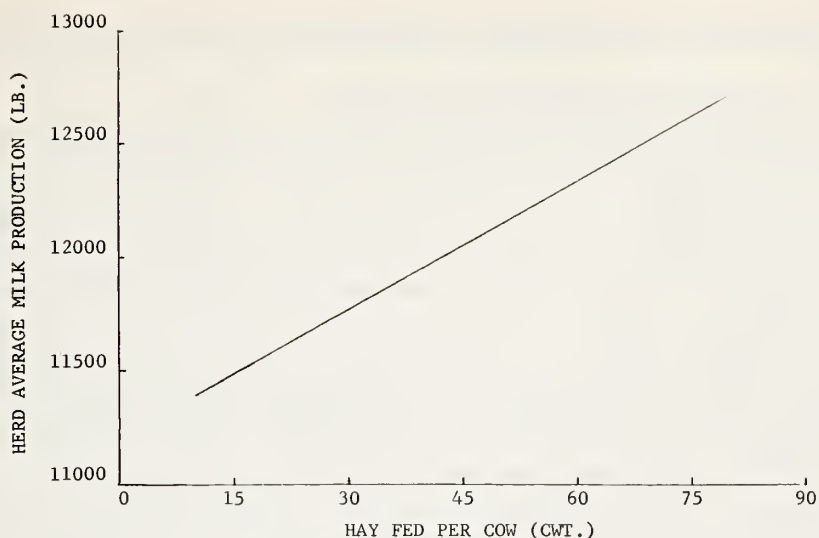


Figure 3.--Relationship between herd average milk production and hay feeding levels, holding grain and other forage intake constant.

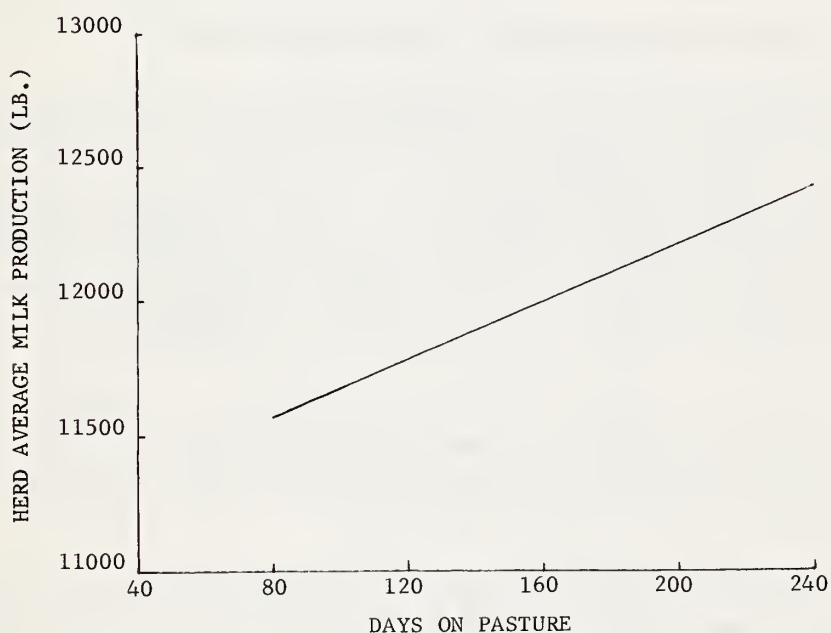


Figure 4.--Relationship between herd average milk production and days on pasture, holding grain and other forage intake constant.

pasture) are somewhat less than might have been anticipated.

The practical implication of this result is that the use of grain in the feeding program is a very important factor in the producing level of the herd. This is a widely recognized fact and has been reflected in the trend toward more liberal use of concentrates in dairy rations over the past several years. In the last ten years there has been a 50 percent increase in the amount of grain fed per cow in DHIA. Successful dairymen now recognize the profitability of feeding high levels of grain to inherently high producing cows. This result, emphasizes the benefits that dairymen can gain from following the principles of lead feeding and challenge feeding that have been widely advocated in recent years. Research and practical experience have indicated that extra concentrates fed in lead feeding and challenge feeding programs will result in the greatest return per dollar invested. The use of grain will necessarily also be affected by the quality and quantity of home-grown forages used.

PREDICTING INCOME OVER FEED COST

The second portion of the study deals with using DHIA estimates to predict the herd average income over feed cost per cow (IOF). Price variables were considered, in addition to the factors previously mentioned. The following factors were evaluated to estimate their influence on IOF: milk, milk price, grain, percent days in milk, silage, hay, pasture, fat percent, and herd size. The results are shown in table 5.

The results in table 5 show the amount of change in IOF for each unit increase in the various factors. As an example, for each 1-dollar increase in the price of milk, there is an increase of \$118.14 in IOF.

These results require careful interpretation. The effects of each factor are measured by observing the change

TABLE 5.--Effects of various factors on herd average income
over feed cost per cow

Factor	Dollar change in income over feed ^{1/} cost per unit change in factor
Milk (100 lb.)-----	+4.30
Milk price (dollars)-----	+118.14
Grain price (dollars)-----	-38.52
Grain (100 lb.)-----	-2.73
Days in milk (1 percent)-----	+.086
Silage (100 lb.)-----	-.36
Hay (100 lb.)-----	-1.07
Pasture (days)-----	-.085
Fat percent (1 percent)-----	-3.22
Herd size (cows)-----	-.015

^{1/} Footnote table 6.

TABLE 6.--Effects of various factors on income over feed cost
when milk production is ignored

Factor	Dollar change in income over feed ^{1/} cost per unit change in factor
Milk price (dollars)-----	+120.33
Grain price (dollars)-----	-23.88
Concentrates (100 lb.)-----	+1.47
Days in milk (1 percent)-----	+5.06
Silage (100 lb.)-----	+.012
Hay (100 lb.)-----	-.35
Pasture (days)-----	+.13
Fat percent (1 percent)-----	+3.96
Herd size (cows)-----	-.06

^{1/} Effect of the factor when all other factors remain the same.

in IOF when all other factors remain the same. Thus, for example, when all other variables are held constant, there is a decrease of \$2.73 in IOF for each 100-pound increase in the amount of concentrates fed. The reasonableness of this result can be seen by remembering that this effect is obtained by holding all other factors, including milk and milk price, constant. For example, if the cows in a herd are fed more grain, but production fails to increase, a decrease in IOF will result because of the increased costs. Since milk price is also held constant, there is no way in which income can rise. In the same manner, all the feeding elements show a negative effect. Also, an increase of \$1 in grain price per hundredweight reduces IOF by \$38.52 per cow per year because feed cost is increased while the value of product remains constant.

The factors shown in table 5 give an accuracy of 94.4 percent in the prediction of IOF. Of these variables, percent days in milk, fat percent, and herd size were of no additional value in the prediction.

Milk and milk price were the two next most useful factors for prediction purposes. The effects of the other variables are greatly altered by the inclusion of milk production in the analysis. For example, the effects of the feeding estimates would be exerted almost entirely through their impact upon herd average milk yield. Thus, the results in table 5 are somewhat artificial. For this reason, an additional analysis was carried out excluding milk production, in order to evaluate the total impact of the feed components on IOF. These results are given in table 6.

When milk production is allowed to vary, the results for the feeding factors are entirely different. Grain, silage, and pasture have positive effects, while hay still has a small negative effect on income over feed cost. The negative contribution of hay appears to indicate that the amount dairymen charged for the cost of the hay exceeded the additional income brought about by increased hay feeding. As seen in table 4, increases in the estimated hay fed did result in higher milk yield.

The factors in table 6 give an accuracy of 46.7 percent in the prediction of IOF. Of the nine variables, herd size, fat percent, and silage were found to be of little use in improving the accuracy of prediction. While silage had a positive relation to IOF, the added returns per unit fed were so small as to be inconsequential.

The most important factors, in order of importance, were: milk price, percent days in milk, concentrates, grain price, pasture, and hay.

SUMMARY

The results of this study and their implications can be summarized as follows: (1) There is a strong relationship between milk yield and income over feed cost, so that production level is an accurate indication of the economic success of the dairy enterprise, excluding the question of the efficiency of the use of capital and labor. (2) Estimated concentrate feeding is the most important feeding criterion measured in DHIA, and is strongly associated with herd average milk production and IOF. The results indicate that the proper use of liberal concentrate feeding, particularly to high-producing cows, is a key attribute of successful dairy management. (3) The proportion of the year that cows are in milk is an important management attribute. This factor reflects (a) the inherent producing ability of the herd, (b) feeding and labor management characteristics in the herd, and (c) the level of reproductive efficiency in the herd. (4) DHIA forage estimates (hay, silage, pasture) are of little value in predicting income over feed cost and milk production of a herd, perhaps due to the wide variations in energy content of forage. (5) DHIA forage estimation procedures need to be sharpened in order to make these estimates more useful than they are at present. This may be achieved by wider use of forage testing and by training programs designed to assist dairymen and DHIA supervisors in estimating forage quantities actually consumed.

OFFICIAL BUSINESS

ERRATA: For May 1968 Dairy Herd Improvement Letter,
ARS-44-204, Artificial Insemination (AI) Participation Report
for the United States 1967. Line 1, page 1, should read as
follows: A total of 7,847,607 cows were bred artificially
in the United States in 1967.